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ABSTRACT

A study explored whether cues given in advance of messages presented through noise were effective for increasing comprehension. Specifically, the study examined whether (1) relevant cues increased overall listening accuracy and (2) irrelevant cues impaired listening by introducing distortions into the processing of messages or simply decreased the likelihood that messages would be identified as a whole. Six normally hearing college students were presented with recorded messages--questions--which were masked through speech-shaped noise set at a constant level. A set of relevant and irrelevant cues had been developed for each question. The relevant cues were used as condition A, the no-cue condition was condition B, and the irrelevant cues condition was condition C. The cues were presented on cards to the subjects some five seconds before they heard the message (blank cards were used for condition B). The subjects answered each question and then repeated as much of it as they could hear. Results supported the view of listening as a process of locating in memory particular knowledge of a topic and then comprehending various messages related to that topic. In the case of irrelevant cues, the main effect was that of inhibiting the process of locating the topic: no real evidence for distortion associated with the irrelevant cues as a factor in listening accuracy was found. (FL)

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COMPREHENSION, MESSAGE INTELLIGIBILITY, AND KNOWLEDGE OF THE TOPIC: A SUPPLEMENTARY INVESTIGATION

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The present study represents a follow-up investigation of data gathered in connection with a previously reported study (Garrett and Saint-Pierre, 1980). In the original study, cues given in advance of messages presented through noise were shown to be effective for increasing comprehension. A number of investigators (e.g., Hawkins and Stevens, 1950; Speaks, et al., 1972; Kalikow, et al., 1977; Saint-Pierre, 1979; and LaCroix, et al., 1979) have demonstrated that masking the speech signal produces decrements in performance for normally hearing listeners proportionate to the signal-to-noise (S/N) ratio.

In the study by Garrett and Saint-Pierre (1980) cues provided in advance of messages gave either accurate or inaccurate information regarding the topic of the message. The messages were presented at one of three S/N ratios: -5 dB for 25% estimated intelligibility (EI); -3 dB for 50% EI; and -1 dB for 75% EI. The results gave general support for the positive effect of the relevant cues versus the irrelevant cues that reached significance at two of the three S/N ratios included in the study.

However a number of questions were left unanswered concerning the exact operation of the relevant and irrelevant cues: Did the relevant cues increase overall accuracy of listening or only a greater percentage of accurately heard messages? Similarly, did the irrelevant cues impair listening by introducing distortions into the processing of messages or simply decrease the likelihood that messages would be identified and attended to as a whole? One theorist considered in connection with the the original study (Miller, 1965) would seem to favor the latter position

in each of the above cases, i.e., that cues serve to activate areas of memory, relevant cues increasing the probability that the message can be heard and attended to and irrelevant cues simply failing to perform this function or possibly inhibiting it. By looking at both accuracy and inaccuracies within message reports the above questions can be answered.

Tape-recordings were made of the data gathering sessions which permitted subsequent analysis of the Ss' responses. Variables such as length of response, words reported correctly and incorrectly, and percentage of correct words per response can be examined for each of the nine experimental conditions. The results for these analyses are given below.

Methods and Procedures

Details for the original investigation can be found in Garrett and Saint-Pierre (1980) and therefore will only be briefly summarized here. Messages, one of 45 questions, were presented through masking speech-shaped noise set at a constant level of 75 dB SPL at S/N ratios of -5 dB, -3 dB, or -1 dB (25% EI, 50% EI, and 75% EI, respectively). A set of relevant and irrelevant cues was developed for each question. The relevant cues were used as Condition A; the no cue condition was Condition B; and the irrelevant cues were used as Condition C. An example of a relevant cue is "Things that grow in the garden" for the question: "What is the color of a cucumber?" The irrelevant cue for this question was "Things you can chew." These cues, typed on 3 x 5 cards, were presented by placing them before the Ss about 5 seconds prior to the presentation of the question. Blank cards were used for Condition B in the same fashion. The three S/N ratio conditions were combined with the three cue conditions in a partially counterbalanced 3 x 3 factorial design which controlled for cue conditions within each S/N ratio condition.

The experimental conditions were presented using a Grason-Stadler, 1701 audiometer to mix and attenuate the messages at the desired S/N ratios before they were fed into a set of headphones to be presented monaurally to the right ear of the Ss.

The Ss were six normally hearing student volunteers, 3 M and 3 F, ages 20 to 32. The Ss were given the cue (or blank card in the case of Cond. B) and then listened to the question, presented at one of the three S/N ratios. Their instructions were first to answer the question and then repeat as much as they were able to hear so that their responses could be recorded for later analysis. The Ss also rated each cue, when given, on a 5-point scale before the next question was presented.

Results and Discussion

The original analysis revealed that the cues were perceived differently in terms of their relevance ($F = 89.7$, $p < .001$) and the ANOVA for the percentage of the questions answered correctly under each condition also yielded significant results for the cue conditions ($F = 6.86$, $p < .01$) and for the S/N ratios affecting intelligibility ($F = 6.23$, $p < .01$). It was therefore expected that these same differences would be present for the analysis of the Ss' responses for variables such as length of response and accuracy, i.e., Cond. A > Cond. B > Cond. C for the cue conditions and 75% EI > 50% EI > 25% EI for the S/N ratio conditions.

Length of Response

Data tabulated from transcripts made from the Ss' tape-recorded responses produced the results reported in Table 1. As can be seen in Table 1, the results provide directional support for the above prediction

Insert Table 1 about here

except in the case of Cond. B at the 25% EI level which is slightly less than the 2.4 observed at the 25% EI level for Cond. C.

An ANOVA was performed for the mean length of response with the results presented in Table 2. The F for the cue conditions approached

Insert Table 2 about here

significance ($F = 2.76$, $df = 2/45$, $p < .10$) and the difference between S/N ratios reached the 99% confidence level ($F = 7.05$, $df = 2/45$, $p < .01$). There is some cause for puzzlement here because while the cue conditions were clearly separated in the original analysis based upon comprehension of the questions, this difference failed to manifest above the 90% confidence level in the present analysis of response length. Comprehension may thus be only indirectly rather than directly related to response length.

Trend tests were carried out for the differences between treatment means according to the procedure for such comparisons as discussed by Winer (1962, pp. 65-70). The test for a linear trend reached significance for the S/N ratios under Cond. B ($F = 8.02$, $df = 1/45$, $p < .01$) The differences for the S/N ratios under Cond. A and C reached the 90% confidence level ($F = 2.98$ and $F = 3.17$ respectively, $df = 1/45$, $p < .10$)

Before proceeding it might be well to discuss a possible problem in connection with both the present and subsequent analyses. Because the conditions were not counterbalanced for the S/N ratio conditions and the questions were not of uniform length (5 to 9 words depending upon the presence of functional words, e.g., indefinite articles) it might be suspected that these uncontrolled differences in length might have contributed to the significant difference for the S/N ratios. However the mean message lengths for the S/N ratio conditions (5.6 wds. at 25% EI, 6.2 wds. at 50% EI, and 5.9 wds. at 75% EI) would not seem to differ by a great enough amount to have influenced the result.

Words Correctly Reported

Attention was next given to the number of words correctly reported by the Ss for each message. The means (see Table 1) are again in the predicted direction, but when an ANOVA was performed (Table 3) the F-ratio for the cue conditions was only 1.45, NS. The difference between S/N ratios

Insert Table 3 about here

reached the 95% confidence level ($F = 3.47$, $df = 2/45$, $p < .05$). A test for linear trends, in this case for the S/N ratios within cue conditions approached significance only under Cond. B ($F = 3.64$, $df = 1/45$, $p < .10$).

The fact that the above analysis, focusing only on the correctly reported portion of messages, failed to discriminate between successful and non-successful listening performance for the cue conditions A, B, and C may be taken as partial confirmation of the previous conclusion offered in connection with the analysis for the mean length of response. That is, the absence of a significant difference between the cue conditions indicates that a goodly portion of the messages were being heard under Cond. B and C even though listening was sufficiently disrupted to affect performance in terms of comprehension. This might suggest that the missing ingredient is not so much hearing the words as interpreting and following their meaning. In contrast, the significant difference present because of intelligibility in terms of the S/N ratios can be straightforwardly interpreted as being due to difficulty in hearing the words of the message.

Percent Correct

Analysis was next performed for the percent correct among words reported per message in the hope that this greater refinement, focusing on the accuracy of the response for each message, might yet show a significant difference in the processing of the messages between cue conditions. It

might be noted that the statistic of words correct remains insensitive to differences in responses where in one case 3 out of 6 (i.e., 50%) of the response was accurate and another case where 3 out of 3 (= 100%) of the report was accurate. While it should be more sensitive to differences in accuracy, however, the percent correct statistic is still ambiguous: differences between cue conditions could indicate either greater accuracy due to the relevant cues in Cond. A or be evidence of distortion associated with the irrelevant cues of Cond. C, or both.

The data for percent correct among words reported (for means see Table 1) were subjected to ANOVA with the results reported in Table 4.

Insert Table 4 about here

This time the F-ratio for the cue conditions reached the 95% confidence level ($F = 3.80$, $df = 2/45$, $p < .05$). Comparisons between individual means reached the 90% confidence level only under the 25% EI level ($F = 2.88$, $df = 1/45$, $p < .10$) with lesser significance for the 50% and 75% EI levels ($F = 2.78$ and 1.99 respectively, $df = 1/45$, $p < .25$). Thus differences in accuracy decreased as intelligibility increased, as is also indicated by the highly significant difference found for the S/N ratios ($F = 6.67$, $df = 2/45$, $p < .01$). Individual comparisons for the S/N ratios again showed the greatest difference under Cond. B ($F = 7.61$, $df = 1/45$, $p < .01$) with lesser significances for Cond. A and C ($F = 2.62$ and 3.63 respectively, $df = 1/45$, $p < .10$). We now have evidence for a difference in accuracy of listening between the cue conditions; it remains to discover whether it is the result of actual increased accuracy associated with the relevant cues or, alternatively, whether distortions are responsible for less accuracy under Cond. C.

Incorrectly Reported Words

A direct test of the possibility that the irrelevant cues in Cond. C were producing distortions in listening can be accomplished by looking at the instances where words were incorrectly reported under each condition. The means in this case (see Table 1) show no appreciable differences among the cue conditions ($\overline{X}$, Cond. A = 0.61; $\overline{X}$, Cond. B = 0.62; and $\overline{X}$, Cond. C = 0.64). An ANOVA performed for this data gave an F-ratio of less than one for both main effects and no significant interaction (F = 1.28, NS).

Thus the theorizing by Miller (1965) would seem borne out; cues identifying the topic of messages activate relevant areas of memory which prepare the listener to hear and follow the meaning of the message. A greater ability to "tune in" to the message must be responsible for the increase in performance associated with the relevant cues. The irrelevant cues, rather than producing distortions in listening, simply cause an inappropriate listening set, decreasing the likelihood of the listener's detecting that actual topic and sense of the message. Of course distortions in listening do occur and there were some cases in the present data to indicate this. For example, on one case a S reported hearing the word "hamburgers" when the irrelevant cue was "Things you can eat" which had nothing to do with the question in this case: "Which is bigger a man or a baby?" However, their incidence, as indicated by the present data at least, was not a significant factor in the listening process.

Analysis for Performance Index

In showing a significant difference in performance for the cue conditions, the analysis for the percentage correct among the words reported in a given response is somewhat encouraging in the support it lends to the above interpretation for the effect of the relevant cues. However, it will

be noted that this statistic fails to distinguish between a situation where a S heard only two words correctly out of a total message of seven words (2/2 = 100%) and another case where all seven words were correctly reported (7/7 = 100%). In order to overcome this limitation and the possible interpretation that the previous result might yet be an artifact of the insensitivity of the statistic used, plus bad luck, an index of performance was created: Index = percent correct x percent complete. In the case of the above example this would give an Index value of 28.6% for two words heard correctly in a seven word message and 100% again in the case of a message reported with complete accuracy. In another case two words out of five reported in a seven word message would yield an Index value of 28.4% as compared to the value of 40% in the analysis of percent correct among words reported.

The means for the Index are given in Table 1 and the ANOVA for this data are reported in Table 5. In this analysis the differences among cue

Insert Table 5 about here

conditions reached the 95% confidence level ($F = 3.21$, $df = 2/45$, $p < .05$) and the F-ratio for the S/N ratios was again highly significant ($F = 7.91$, $df = 2/45$, $p < .01$). Overall the results do not appear to differ much from what was seen in the case of the earlier analysis of percent correct.

Trend tests for the cue conditions reached the 90% confidence level under the 25% EI level ($F = 2.88$, $df = 1/45$, $p < .10$) and reached the 75% confidence level for the 50% EI level. Cond. B again exhibited the most significant linear trend across S/N ratios ($F = 8.18$, $df = 1/45$, $p < .01$) while Cond. A and C reached the 90% confidence level ($F = 3.08$ and 3.94 respectively, $df = 1/45$, $p < .10$).

While adding little information to that achieved from earlier analyses,

the index does serve to further support the conclusions based upon the analysis for percent correct while avoiding some of the weaknesses of this statistic.

Summary

The investigation of listener responses has given some additional information on the effect of the cues identifying the topics of messages under conditions of reduced intelligibility. Support was found for the view of listening as a process of locating in memory particular knowledge of a given topic and then following and comprehending various messages related to that topic. In the case of the irrelevant cues, the main effect seems to be that of inhibiting the process of locating the topic; no real evidence for distortion associated with the irrelevant cues as a factor in listening accuracy was found in the present data.

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TABLE ONE

MEAN PERFORMANCE PER MESSAGE FOR CUE CONDITIONS AND EI LEVELS FOR VARIABLES OF LENGTH OF RESPONSE, WORDS CORRECT AND INCORRECT, PERCENT CORRECT AND PERFORMANCE INDEX

		EI LEVELS			
		25% EI	50% EI	75% EI	$\bar{X}$
COND. A	Length of Response	4.03	4.46	6.07	4.85
	Words Correct	3.50	3.80	5.42	4.24
	Words Incorrect	0.50	0.70	0.63	0.61
	Percent Correct	59.0%	67.4%	82.0%	69.5%
	Performance Index	50.2%	48.9%	76.7%	58.6%
COND. B	Length of Response	1.96	4.03	5.30	3.76
	Words Correct	1.66	3.0	4.8	3.15
	Words Incorrect	0.30	1.06	0.50	0.62
	Percent Correct	38.7%	56.9%	78.0%	57.9%
	Performance Index	24.5%	39.2%	67.6%	43.8%
COND. C	Length of Response	2.40	3.0	4.50	3.30
	Words Correct	1.60	2.50	3.90	2.67
	Words Incorrect	0.80	0.50	0.60	0.64
	Percent Correct	34.9%	43.7%	62.0%	46.9%
	Performance Index	24.7%	32.6%	53.8%	37.1%
$\bar{X}$	Length of Response	2.80	3.80	5.28	
	Words Correct	2.25	3.10	4.70	
	Words Incorrect	0.54	0.76	0.58	
	Percent Correct	44.2%	56.0%	73.9%	
	Performance Index	33.1%	40.3%	66.0%	

TABLE 2

TWO-WAY ANOVA FOR MEAN LENGTH OF RESPONSE PER MESSAGE

Source of Variation	MS	df	F	p
Cue Conditions	11.47	2	2.76	<.10
EI Levels	29.26	2	7.05	<.01
Interaction	0.81	4	<1	
Error	4.15	45		

TABLE 3

TWO-WAY ANOVA FOR MEAN NUMBER OF WORDS HEARD CORRECTLY PER MESSAGE

Source of Variation	MS	df	F	p
Cue Conditions	293.39	2	1.45	NS
EI Levels	700.23	2	3.47	<.05
Interaction	17.28	4	<1	
Error	202.02	45		

TABLE 4

TWO-WAY ANOVA FOR MEAN PERCENT CORRECT AMONG WORDS REPORTED PER MESSAGE

Source of Variation	MS	df	F	p
Cue Conditions	2,303.4	2	3.80	< .05
EI Levels	4,041.3	2	6.67	< .01
Interaction	111.9	4	<1	
Error	605.4	45		

TABLE 5

TWO-WAY ANOVA FOR INDEX OF PERFORMANCE

Source of Variation	MS	df	F	p
Cue Conditions	2,181.5	2	3.21	<.05
EI Levels	5,381.0	2	7.91	<.01
Interaction	161.4	4	<1	
Error	679.9	45		